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(54) **A method of repairing a ceramic coating**

(57) It is a method of repairing a ceramic coating of an article after use of this article in a high temperature environment disclosed. The ceramic coating is removed locally at spalled areas, at the areas where the ceramic coating is removed locally a mixture including a powder

of zirconia stabilized with one or a combination of yttria, calcia, scandia, magnesia, ceria and oxides of the rare earth group, and hydrated metallic halides as a binder is applied and the applied ceramic powder is dried.

## Description

### FIELD OF INVENTION

[0001] The invention relates to a process of repairing a ceramic coating of a component according to the preamble of claim 1.

### STATE OF THE ART

[0002] Components designed for the use in the area of high temperature, e.g. blades or vanes of a gas turbine, are usually coated with environmentally resistant coatings. The coating protects the base material against corrosion and oxidation due to the thermal effect of the hot environment and consists of an alloy mostly using the elements Al and Cr. Most turbine components are coated for protection from oxidation and/or corrosion with, for example, a MCrAlY coating (base coat) and some are also coated with a thermal barrier coating (TBC) for thermal insulation. MCrAlY protective overlay coatings are widely known in the prior art. They are a family of high temperature coatings, wherein M is selected from one or a combination of iron, nickel and cobalt. As an example US-A-3,528,861 or US-A-4,585,418 disclose such kind of oxidation resistant coatings. US-A-4,152,223 as well discloses such method of coating and the coating itself.

[0003] Furthermore, in the state of the art Thermal-Barrier-Coatings (TBC) are known from different patents. US-A-4,055,705, US-A-4,248,904, US-A-4,321,311 or US-A-4,676,994 disclose a TBC-coating for the use in the turbine blades and vanes. The ceramics used are yttria stabilized zirconia and applied by plasma spray (US-A-4,055,705, US-A-4,248,940) or by electron beam process (US-A-4,321,311, US-A-4,676,994) on top of the MCrAlY bond coat.

[0004] The demands of operation of the parts in a gas turbine often lead to the degradation of the coating before the structural integrity of the underlying part itself is degraded. Hence, the base coat and TBC must be removed and reapplied. Such processes are known from EP-A2-813 930, EP-A1-298 309, US-A-6,158,957, US-A-6,132,520, US-A-6,146,692, US-5,728,227, US-A-5,614,054 and US-A-5,900,102. Many of these inventions such as US-A-5,972,424, US-A-6,158,957, US-A-6,132,520 and US-A-6,146,692 deal with the removal of TBC by caustic treatment in an autoclave at modest to elevated temperatures and pressures. A second method often used is the gaseous fluoride treatment such as gaseous hydrogen fluoride as disclosed in US-A-5,728,227 or US-A-5,614,054. Yet in another method, US-5,900,102, the TBC was removed by treatment with a mixture of powders consisting of a halogen containing activator (i.e. ammonium fluoride, chloride etc), aluminum metal and inert alumina as a filler, again the reaction product is a gaseous fluoride, as in the above citations. It is to be noted that although the above

inventions teach us only the methods of removing the damaged TBC from a component, none of them provide any new or noble method or a process for re-coat of the component from where TBC was removed - simply the TBC in the prior art was reapplied by the conventional plasma spray method.

[0005] However, in the prior art US-A-5,759,932 and US-A-5,985,368 disclose methods wherein the TBC is applied on the surface using a slurry. In essence the powdered yttria stabilized zirconia with/without porous zirconia spheres is blended in a paint mixer with a silicone resin, SR-350 and a lubricant, UVCON-50MB-2000.

[0006] It is also known that turbine blades and other components have only local areas of extremely high surface temperature during operation, whereas the rest of the component surface has a moderate temperature. This means that the environmentally protective coatings are degraded by far the most in these local areas of high temperature, which constitute about 5 to 20 % of the total surface area of the whole component, and only moderately over the rest of the surface area.

### SUMMARY OF THE INVENTION

[0007] It is object of the present invention to find a method of locally repairing thermal barrier coated components. This method should be especially suitable for the local repair of turbine blades and vanes of both aircraft and industrial gas turbine engines. Another objective is to prove a method of repairing a TBC on a site in the field.

[0008] According to the invention a method was found of repairing an article with a ceramic coating according to the preamble of the claim 1 wherein

- a. remnants of the ceramic coating adjacent to and inside of the areas of spallation are removed,
- b. the areas of spallation are prepared for local coating application by conventional means such as chemical treatment, grit blasting or abrasive cleaning,
- c. on the areas of spallation is applied a mixture including a powder of zirconia stabilized with one or a combination of yttria, calcia, scandia, magnesia, ceria and oxides of the rare earth group, and hydrated metallic halides as a binder, after which
- d. the applied mixture of ceramic powder and binder is dried.

[0009] With advantage the mixture of stabilized zirconia powder and hydrated metallic halides as a binder is prepared as a slurry with water alone or with water in combination with alcohol using hydrated aluminum chlorides before applying to the mentioned areas. The viscosity of the slurry can be adjusted by the addition of distilled water alone or by the addition of water in combination with alcohol to obtain a suitable flowability dur-

ing spraying. In some cases the viscosity of the hydrated metallic hydride will be sufficient that no water or alcohol need be added to the slurry to achieve the desired properties. Hollow zirconia spheres could be added to the mixture of stabilized zirconia powder and hydrated metallic hydrides in order to offer the advantage of a higher effective porosity content of the TBC.

[0010] In one embodiment, the slurry coating is dried at a temperature between 20°C and 100°C and finally heat-treated at 55° to 750° C to remove the evolving halogens, halogen gas, or residual water.

[0011] This method saves both time and investment costs because stripping and re-coating the entire surface area of the component using conventional means such as plasma spraying is unnecessary.

[0012] The hydrated metallic halide binder can consist of one or a combination of hydrated metallic halide components such as hydrated aluminum chloride and/or hydrated halides of magnesium, calcium, yttrium, zirconium, strontium, barium, including other hydrated halides of the rare earth group or group 11 alkaline halides.

[0013] In another embodiment of the invention, the sizes of individual powder particles of the stabilized zirconia powder range from 5 to 150 µm to offer the advantages of greater strength and lifetime on the component during service.

[0014] This invention is particularly useful when applied to articles such as blades, vanes or any other gas turbine component operating at high temperatures and coated with a TBC.

#### DETAILED DESCRIPTION OF INVENTION

[0015] The invention is related to a process of repairing an article with a TBC-coating being exposed to a high temperature environment or damaged due to the transport after the manufacture. The damage received by the component consists of spallation of the TBC localized to the areas of highest temperatures experienced during service or areas which were impacted due to Foreign Object Damage during service in the gas turbine. For the case of damage during shipping or other transport, the areas affected are localized to areas of impactation of the TBC on another hard object due to improper handling or packing. The article could possibly be a blade or a vane or any other part of a gas turbine engine such as a part of a burner chamber exposed to the hot gases of the gas turbine, the article being coated with a MCrAlY-coating to protect it against oxidation. On top of the MCrAlY there is a Thermal Barrier Coating known e.g. from different patents US-A-4,055,705, US-A-4,248,904, US-A-4,321,311 or US-A-4,676,994.

[0016] As base material often used is a superalloy e.g. Ni or Co based. A Ni based superalloy is disclosed in the patent US-A-5,759,301.

[0017] It is well known to those skilled in the art that the types of localized damage described above have little or no effect on the lifetime of the TBC on the rest of

the component. However, the TBC immediately surrounding the areas of spallation is often weakened and must be removed, and additionally there are often small residual amounts of TBC left on the area of spallation.

5 Therefore according to the invention all the weakened TBC material adjacent to the area of spallation must be removed in order to insure a high quality repair, and any residual TBC within the general area of spallation must be removed to ensure proper bonding of the TBC repair material. The ceramic TBC coating could be removed locally by any conventional abrasive means such as grit blasting or grinding, and/or by a chemical stripping such as chemical etching using an acid and/or a mixture of acids. Any residual oxidized MCrAlY material from the bondcoat should also be removed by the above means to provide a high quality surface for the repair material to be applied.

[0018] At the areas where the ceramic coating is removed locally, a mixture including a powder of zirconia stabilized with one or a combination of yttria, calcia, scandia, magnesia, ceria and oxides of the rare earth group, and hydrated metallic halides as a binder is applied and the applied mixture is dried at moderate temperatures, whereby the constituents are tenaciously bound together. In one embodiment, the slurry coating is dried at a temperature of 20° to 100°C and is then finally heat-treated at 55-750°C to remove the evolving halogen compounds, halogen gases or residual water and/or alcohol.

30 [0019] The mixture of stabilized zirconia powder and hydrated metallic halides may offer the desired consistency, viscosity, bonding properties, and drying properties without any further addition. However, in some cases it is advantageous to make additions of distilled water and/or alcohol to the mixture in order to further control the viscosity of the slurry and obtain a suitable flowability during application.

[0020] The hydrated metallic halide binder can consist of one or a combination of hydrated metallic halide components such as hydrated aluminum chloride and/or hydrated halides of magnesium, calcium, yttrium, zirconium, strontium, barium, including other hydrated halides of the rare earth group or alkaline halides (group of the periodic system of the elements). The hydrated metallic hydrides are particularly advantageous to use as binders in this application. It is known to those skilled in the art that, e.g. hydrated aluminum chloride when exposed to elevated temperatures will decompose to hydrogen chloride and water, which leave as gases, and alumina which bonds the yttria stabilized zirconia powder to itself and to the substrate and provides alpha alumina in the TBC known to provide oxidation resistance.

[0021] In an advantageous embodiment, the sizes of individual powder particles of the stabilized zirconia powder ranges from 5 to 150 µm to offer the advantages of greater strength and lifetime on the component during service.

[0022] The mixture of stabilized zirconia powder and

hydrated metallic hydrides can be applied by painting, slurry spraying, or as a paste. Furthermore, in some cases it is advantageous to apply an initial layer of highly fluid slurry in order to maximize wetting of the local area to be repaired and provide good bonding of the next layer of repair material to the surface, and then apply a more viscous version of the slurry in order to ensure optimal structure during drying.

[0023] The method according to the present invention saves both time and investments costs because stripping and re-coating the entire TBC-coated portion of the component using conventional means such as plasma spraying is unnecessary. A further advantage is that the repair process is rapid, and if the appropriate equipment is used, can be carried out in the field with no need for detachment of the component from the engine assembly, nor any need for sending the component to a repair shop.

[0024] The invention is particularly advantageous when applied to a blade or a vane or any other gas turbine component consisting of a nickel or cobalt base alloy exposed to a high temperature environment and coated with TBC.

#### Claims

1. A method of repairing a ceramic coating of an article after damage due to the transport after manufacture or use of this article in a high temperature environment, wherein
  - a. remnants of the ceramic coating adjacent to and inside of the areas of spallation are removed,
  - b. the areas of spallation are prepared for local coating application by conventional means such as chemical treatment, grit blasting or abrasive cleaning,
  - c. on the areas of spallation is applied a mixture including a powder of zirconia stabilized with one or a combination of yttria, calcia, scandia, magnesia, ceria and oxides of the rare earth group, and hydrated metallic halides as a binder, after which
  - d. the applied mixture of ceramic powder and binder is dried.
2. The method of claim 1, wherein the mixture of stabilized zirconia powder and hydrated metallic halides as a binder is prepared as a slurry with water alone or with water in combination with alcohol using hydrated aluminum chlorides before applying to the mentioned areas.
3. The method of claim 2, wherein the slurry is dried at a temperature between 20°C and 100°C and finally heat-treated at 55° to 750°C.
4. The method of claim 2, wherein hollow zirconia spheres are included in the mixture of stabilized zirconia powder and hydrated metallic hydrides.
5. The method of claim 1, wherein the hydrated metallic halide binder consists of one or a combination of hydrated metallic halide components such as hydrated aluminum chloride and/or hydrated halides of magnesium, calcium, yttrium, zirconium, strontium, barium, including other hydrated halides of the rare earth group or group 11 alkaline halides.
6. The method of claim 1, wherein the sizes of individual powder particles of the stabilized zirconia powder ranges from 5 to 150 µm.
7. The method of claim 1, wherein the mixture of stabilized zirconia powder and hydrated metallic hydrides is applied by painting, slurry spraying, or as a paste.
8. The method of claim 1, wherein the article is a blade or a vane or any other part of a gas turbine engine consisting of a nickel or cobalt base alloy exposed to a high temperature environment coated with TBC.



European Patent  
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# EUROPEAN SEARCH REPORT

Application Number  
EP 01 10 9811

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	EP 0 808 913 A (GEN ELECTRIC) 26 November 1997 (1997-11-26) * claims 1,3 * * column 1, line 3 - line 5 * * column 3, line 8 - line 11 * * column 4, line 51 - line 56 * * column 5, line 15 - line 37 * * column 7, line 4 - line 8 *	1,8	C23C24/08 F01D5/28
D,A	US 5 985 368 A (MCATEE DANIEL SCOTT ET AL) 16 November 1999 (1999-11-16) * claims 1-6,15; examples * * column 4, line 23 - line 26 *	1,3,4,6-8	
A	GB 705 102 A (THERMAL SYNDICATE LTD; ARTHUR ERIC JARVIS VICKERS; JOHN BERNARD MALONEY) 10 March 1954 (1954-03-10) * claim 3 *	1,2,5	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			C23C F01D C04B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 September 2001	Examiner Rosenberger, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPF FORM 1503 03.92 (PC4/001)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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EP 01 10 9811

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
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